EERC Technology… Putting Research into Practice

The Plains CO_2 Reduction (PCOR) Partnership

An Overview of Phase II Plans

Regional Carbon Sequestration Partnerships
Phase II Field Validation Test Project Kickoff Meeting

Pittsburgh, Pennsylvania
October 13, 2005

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DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

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Phase II Goals

- Increase public understanding of CO_2 sequestration
- Perform field validation tests that develop:
  - MM&V protocols
  - Regional sequestration strategies
  - Best separation/source matches
  - Regulatory and permitting strategies
  - Environmental benefits and risks
  - Information needed to monetize C credits
- Continued regional characterization
- Regional partnership program integration

PCOR Partnership Region

Nine states and three provinces

1,362,089 square miles

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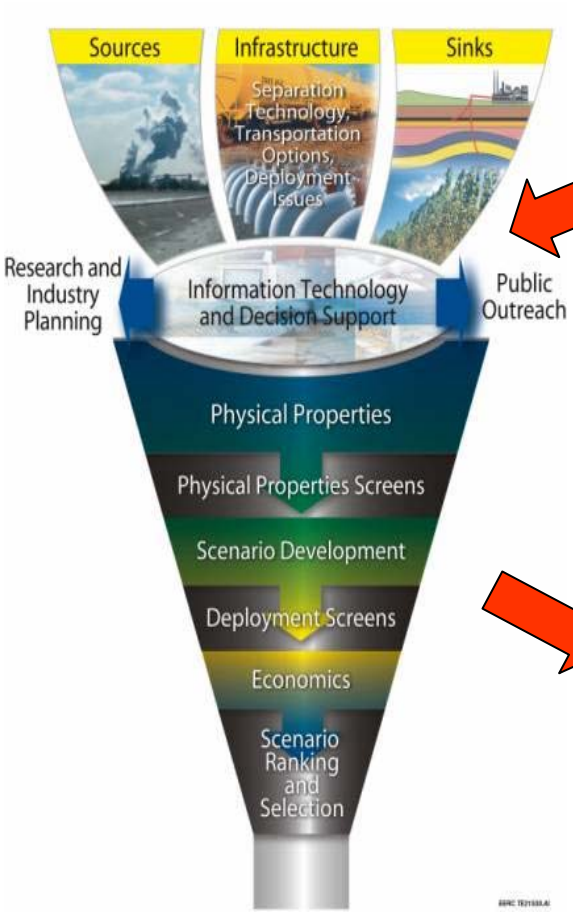
Identifying CO_2 Sequestration Opportunities



Partners

- Acid gas injection into a pinnacle reef for EOR
- Injection into a deep carbonate system for enhanced oil recovery (EOR)
- Injection into a lignite seam for enhanced coalbed methane (ECBM)
- Wetland terrestrial sequestration

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Field Validation Sites

Geologic Demonstrations

- G1 – Beaver Lodge, North Dakota. CO_2 injection site for CO_2 sequestration and EOR
- G2 – Zama, Alberta. Acid gas Injection site for CO_2 sequestration and EOR
- G3 – Lignite coal in North Dakota. CO_2 injected into an unminable lignite coal seam for CO_2 sequestration and possible ECBM production

Terrestrial Demonstration

- T1 – Wetland sites monitored to establish sequestration potential and MMV technologies

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Geologic Field Demonstrations

- Acid gas injection for simultaneous acid gas disposal and EOR in pinnacle reef structure in Alberta.
- CO_2 flood EOR in deep carbonate formation on the Nesson Anticline.
- Injection of CO_2 into North Dakota lignite seam for simultaneous sequestration and enhanced coalbed methane recovery.

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Zama Pinnacle Reef

Injection of acid gas stream from nearby gas-processing plant:

≈ 60% CO_2

≈ 40% H_2S

Approximately 200,000 tonnes of CO_2 will be injected during demo period.

Why Zama?

- Acid gas injection helps evaluate CO_2 purity constraints for future efforts.
- Pinnacle reef structure provides a beautiful container for observation.
- Hundreds of pinnacle reefs exist in the PCOR Partnership region, as well as other worldwide sedimentary basins.

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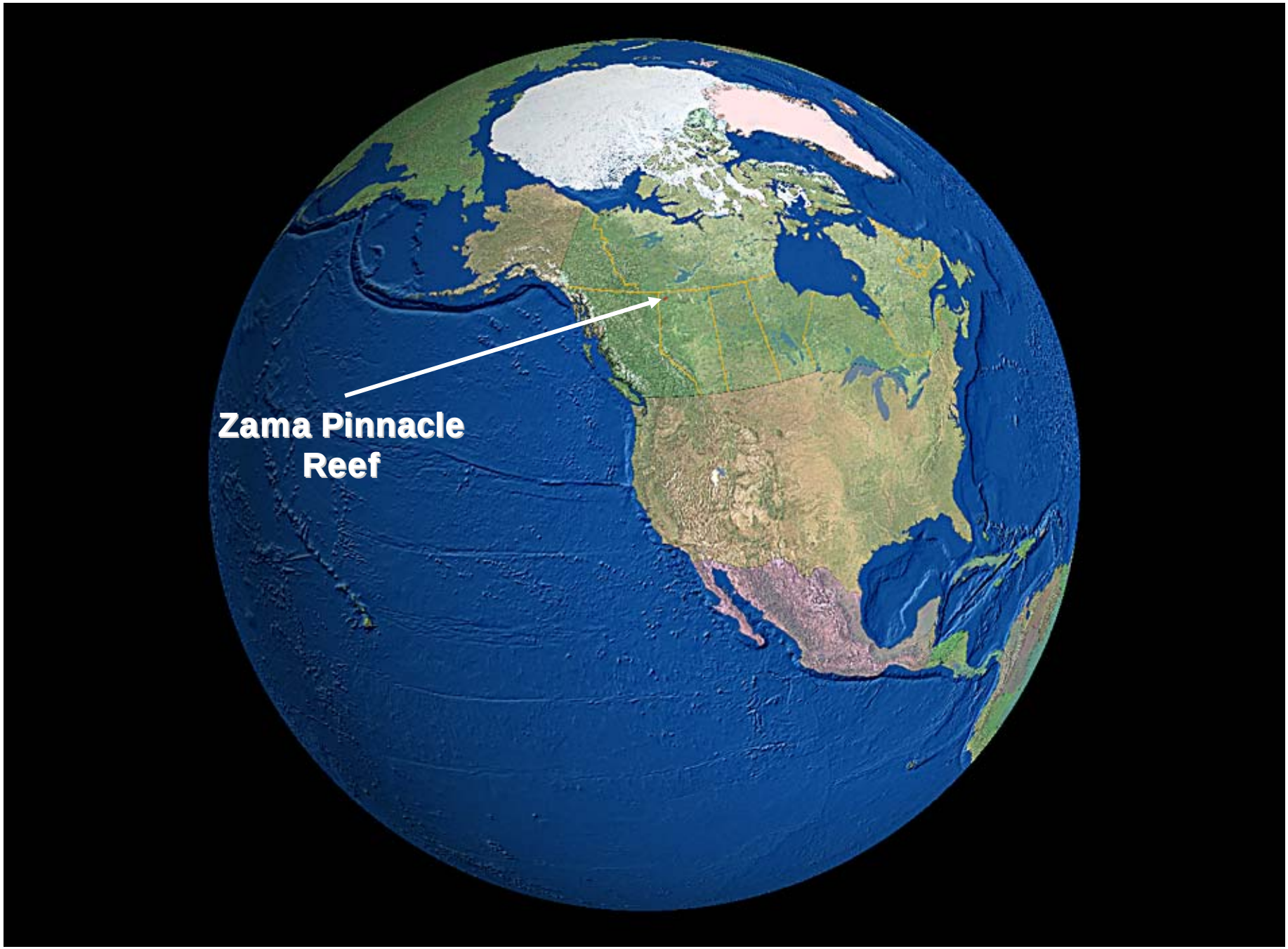
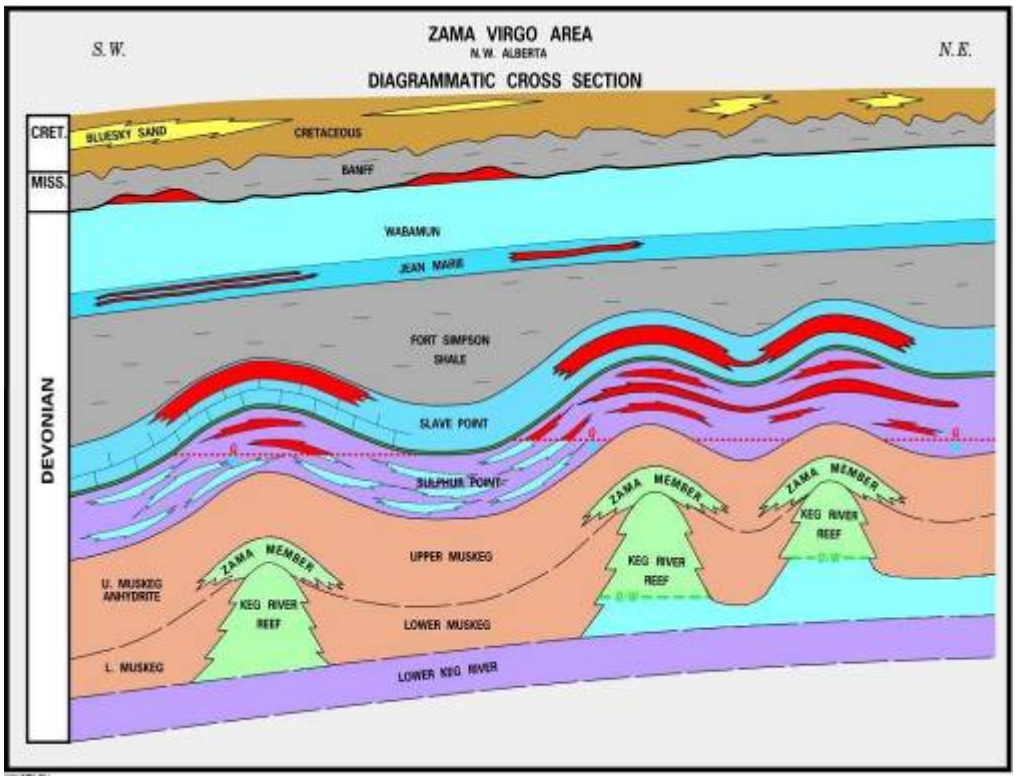

Zama Pinnacle
Reef

Zama Pinnacle Reef (cont.)



Injection Zone Characteristics

- Carbonate reservoir
- Anhydrite seal
- Injection depth = 5300 ft
- Reservoir P = 2210 psig
- Reservoir T = 174ºF
- CO_2 capacity = >1 MMT
- Small size and isolated nature of the pinnacle reef structure make it ideal for study.

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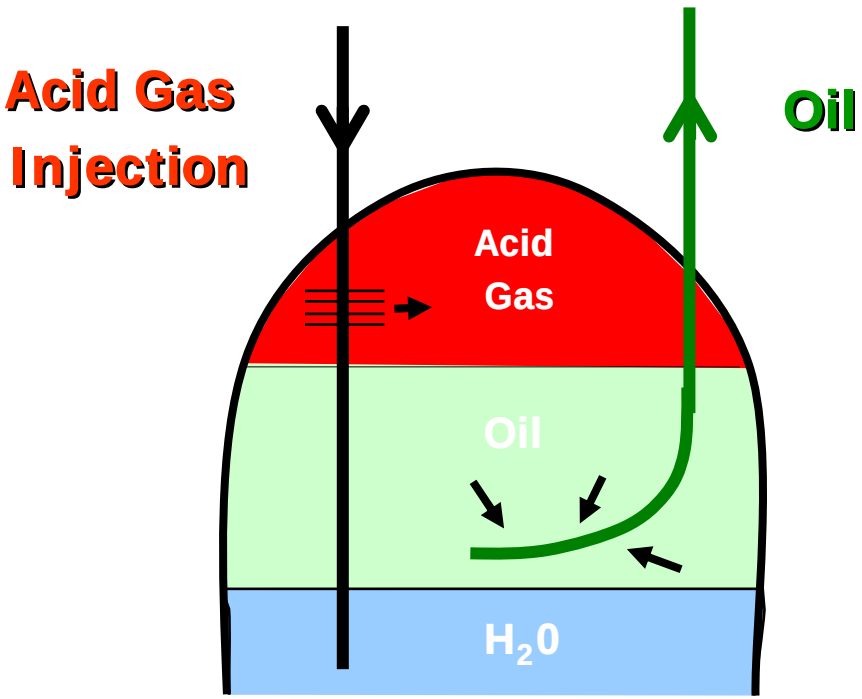
Zama Pinnacle Reef (cont.)



PCOR Partnership Objectives

- Predict, monitor, and evaluate fate of injected acid gas
- Determine effect of H_2S on CO_2 sequestration
- Develop BMP for MMV
- MMV includes:
  - Soil vapor and air quality
  - Shallow and deep aquifer monitoring
  - Produced fluids analysis

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Zama Pinnacle Reef (cont.)

Key Partners

- U.S. Department of Energy National Energy Technology Laboratory
- Energy & Environmental Research Center
- Apache Canada Ltd.
- Alberta Energy and Utilities Board
- North Dakota Industrial Commission Oil & Gas Research Council

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Nesson Anticline (Beaver Lodge Field)

Injection of CO_2 from DGC plant

>95% CO_2

Minimum of 3000 tons of CO_2 will be injected during demo period.

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Why Beaver Lodge ?

- Deepest CO_2/EOR test ever attempted (we think!).
- Structural and stratigraphic trap.
- Stacked units means multiple sequestration targets.

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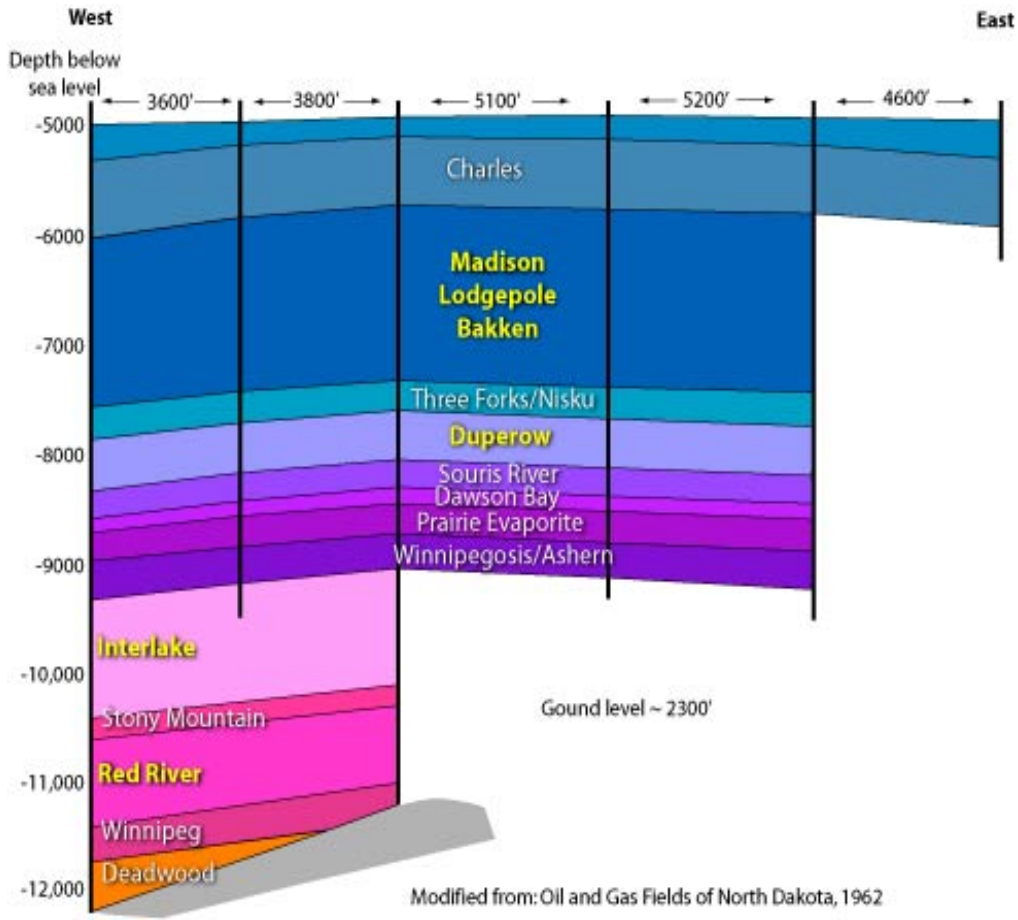
Nesson Anticline (Beaver Lodge Field) (cont.)



Injection Zone Characteristics

- Carbonate reservoir
- Inj.depth = 10,000 ft
- Reservoir P = 3942 psig
- Reservoir T = 249°F
- Salinity = 329,000 ppm
- Capacity >170 MMT

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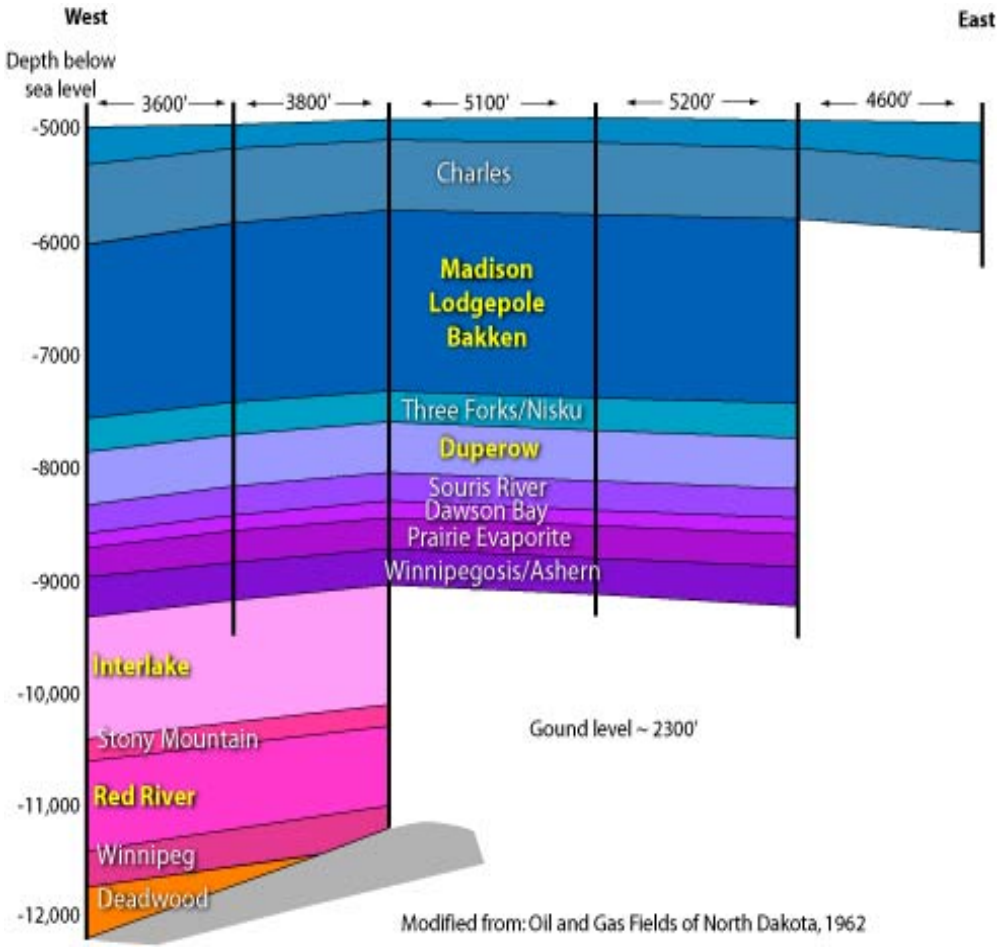
Nesson Anticline (Beaver Lodge Field) (cont.)



PCOR Partnership Objectives

- Predict, monitor, and evaluate fate of the CO_2
- Determine effects of high P&T conditions on CO_2 sequestration
- Develop BMP for MMV
- MMV includes:
  - Soil vapor and air quality
  - Shallow and deep aquifer monitoring
  - Produced fluids analysis, in adjacent units

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Nesson Anticline (Beaver Lodge Field) (cont.)

Key Partners

- U.S. Department of Energy National Energy Technology Laboratory
- Energy & Environmental Research Center
- Amerada Hess Corporation
- North Dakota Industrial Commission Oil & Gas Research Council
- North Dakota Department of Mineral Resources
- Dakota Gasification Company

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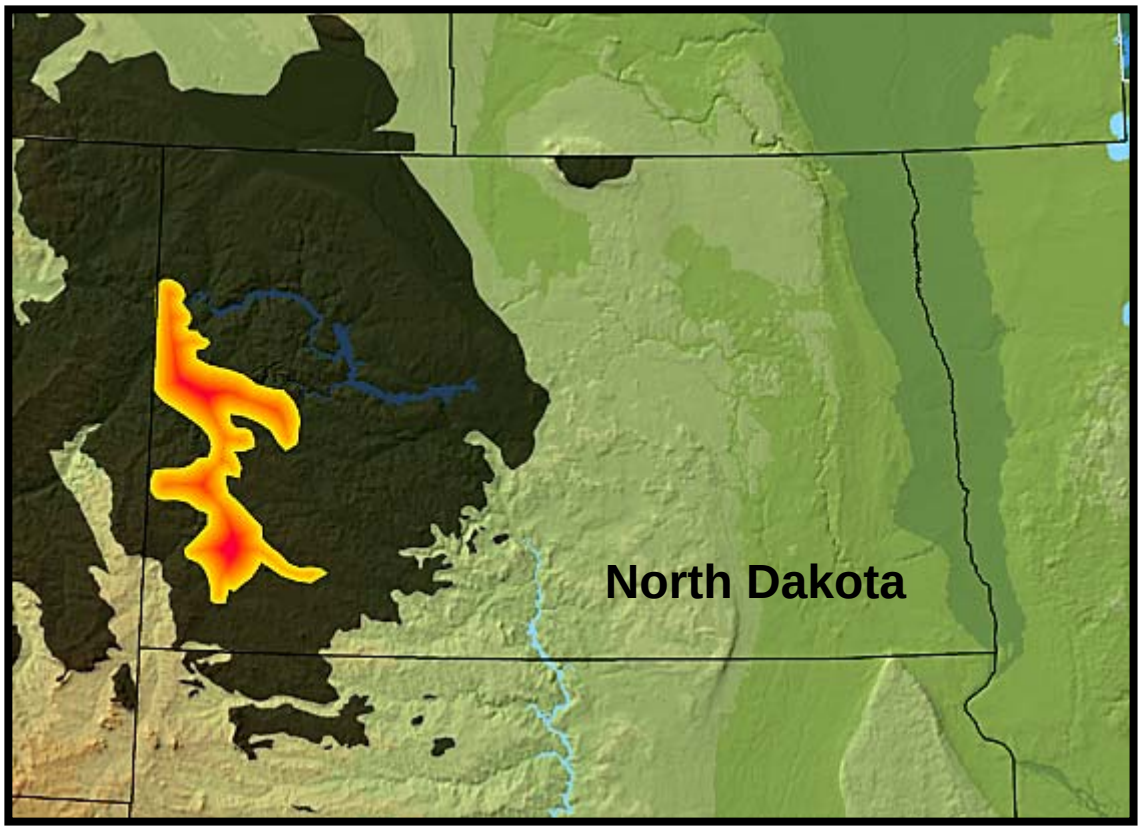
Lignite Coal Seam



Injection of CO_2 from commercial facility

>95% CO_2

Minimum of 1000 tons of CO_2 will be injected during demo period.

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Why Lignite ?

- No CO_2 Injection tests ever conducted in lignite.(We think!).
- CO_2 Adsorption / CH_4 Desorption ratios may well exceed 10.
- Thick regional occurrences of lignite.

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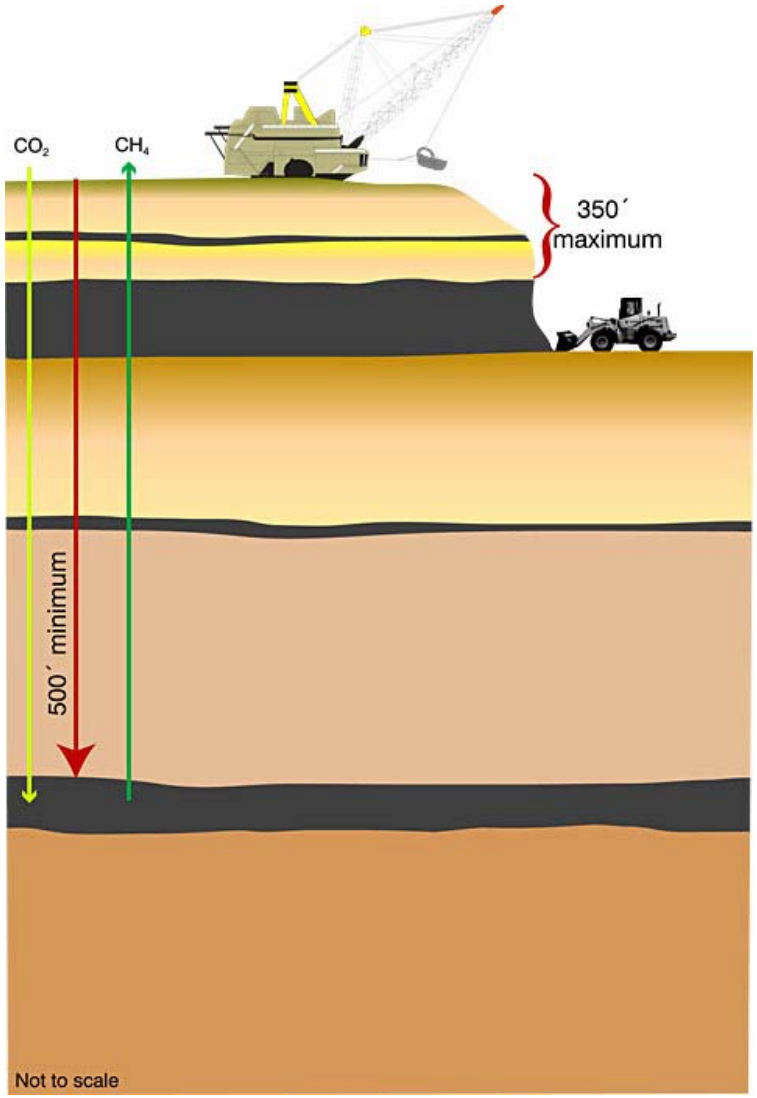
What might happen when CO_2 is injected into a coal bed?*

1. Coal plasticizes and swells. (at least higher rank coals do!)
   Faster molecular diffusion, but could close cleats
2. Water becomes acidic.
   Carbonate minerals dissolve, cleats plug or open
3. Water is removed.
   Coal shrinks and opens cleats
4. Pressure, pH, and temperature gradients develop.
   Minerals are likely to precipitate and plug cleats
   Hydrocarbon solubility will drop
   CO_2 density will drop

injection	outlet
higher P	lower T
geologic T	lower T
low pH	geologic pH

*White et al., *J. Air and Waste Management Assoc.*, vol. 53, pp. 645-715, 2003

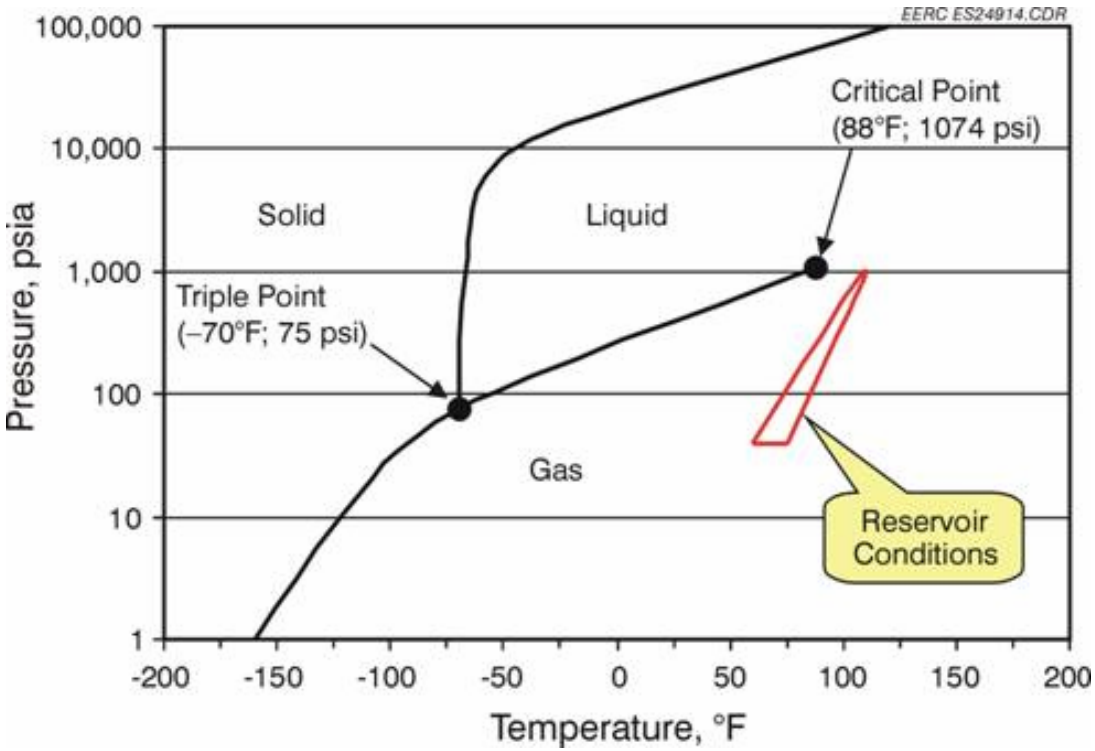
Lignite Coal Seam



Injection Zone Characteristics

- Low-rank coal
- Injection depth
  > 500 ft (150 m)
- Reservoir depth and temperature are low enough that CO_2 will be in gas phase.
- Capacity >300 MMT

Lignite Coal Seam (cont.)



PCOR Partnership Objectives

- Predict, monitor, and evaluate fate of the injected CO_2
- Determine effects of CO_2 on the physical and chemical properties of lignite coal
- Evaluate ECBM potential
- Develop BMP for MMV
- MMV includes:
  - Soil vapor and air quality
  - Shallow groundwater and coal seam water quality

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Lignite Coal Seam (cont.)

Key Partners

- U.S. Department of Energy National Energy Technology Laboratory
- Energy & Environmental Research Center
- North Dakota Industrial Commission Oil & Gas Research Council
- North Dakota Department of Mineral Resources
- Mineral Holder (>40,000 acres)

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Units and Range of Typical Reservoir Conditions

Pressure

75–145 atm (bar)

1100–2500 psi

2540–4920 feet of water

$1.3x10^6$–$2.6x10^6$ slugs/sq. perches

45–87 scrupels/sq. barleycorns*

Temperature

30°–140°C

85°–285°F

User

Chemists
Engineers
Geologists
Biologists
Regulators

Volume
1 scf = 56 g CO_2

Concentration
1000 scf/bbl = 43 wt% (CO_2/oil)

*(estimated based on British barleycorn)

Density
API gravity 1 = 1.076 g/mL
API gravity 100 = 0.6112 g/mL

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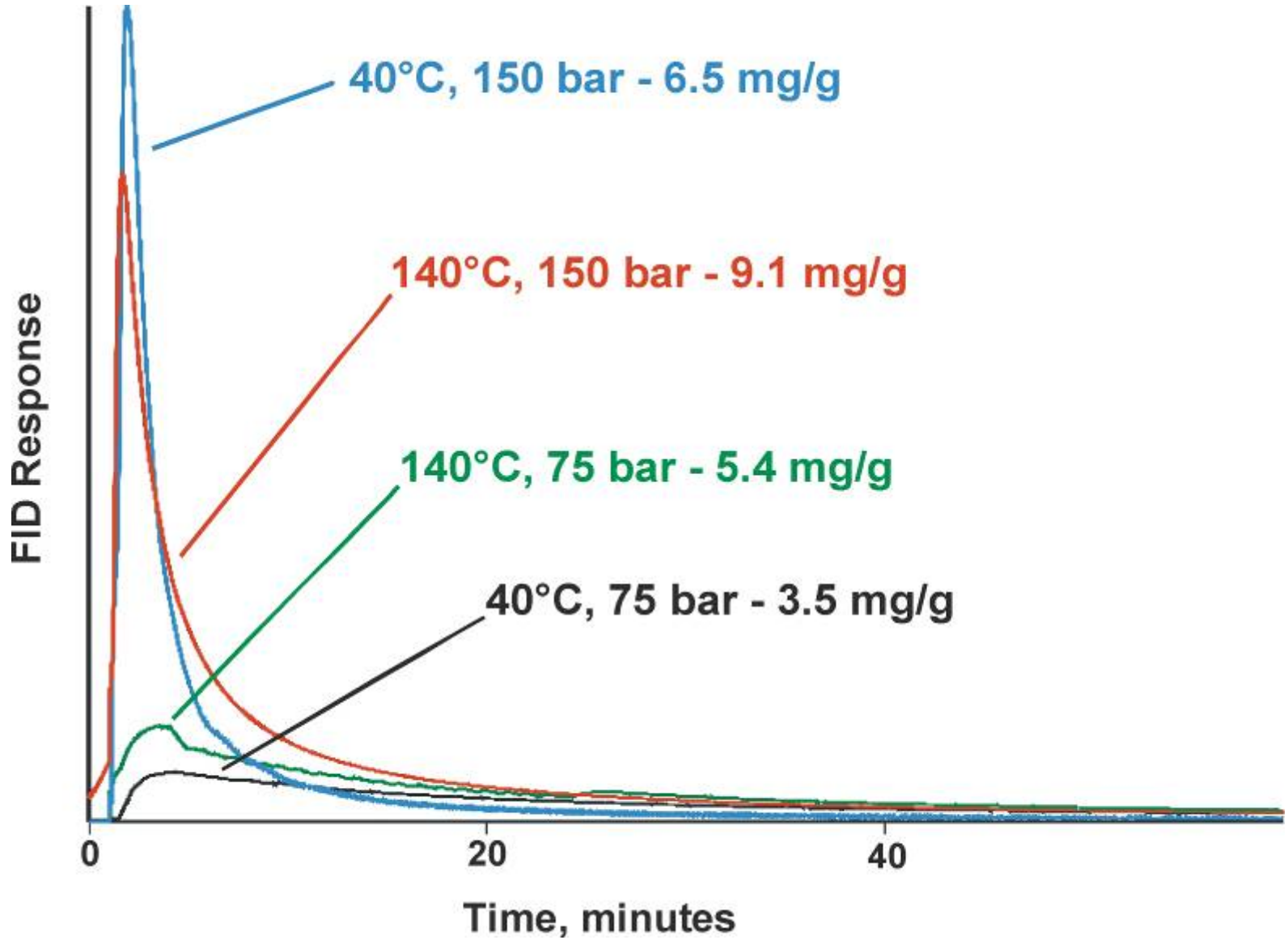
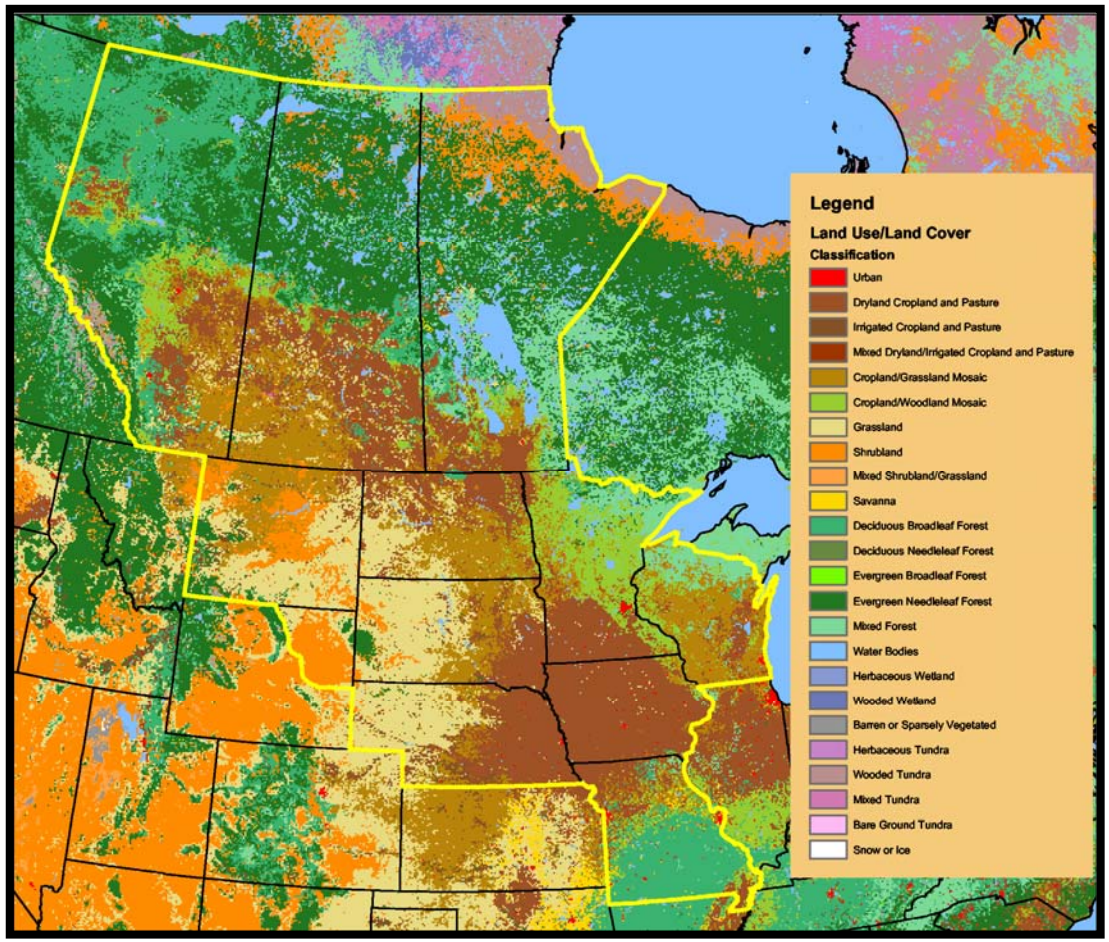
Online FID Determination of Hydrocarbons Extracted from Reservoir Rock with CO_2



Terrestrial Sequestration

- Identify, develop, and apply alternate land use management practices to the Prairie Pothole Region
- Wetlands and grasslands
- EERC; Ducks Unlimited, Inc.; Ducks Unlimited Canada (DUC); and U.S. Geological Survey (USGS)



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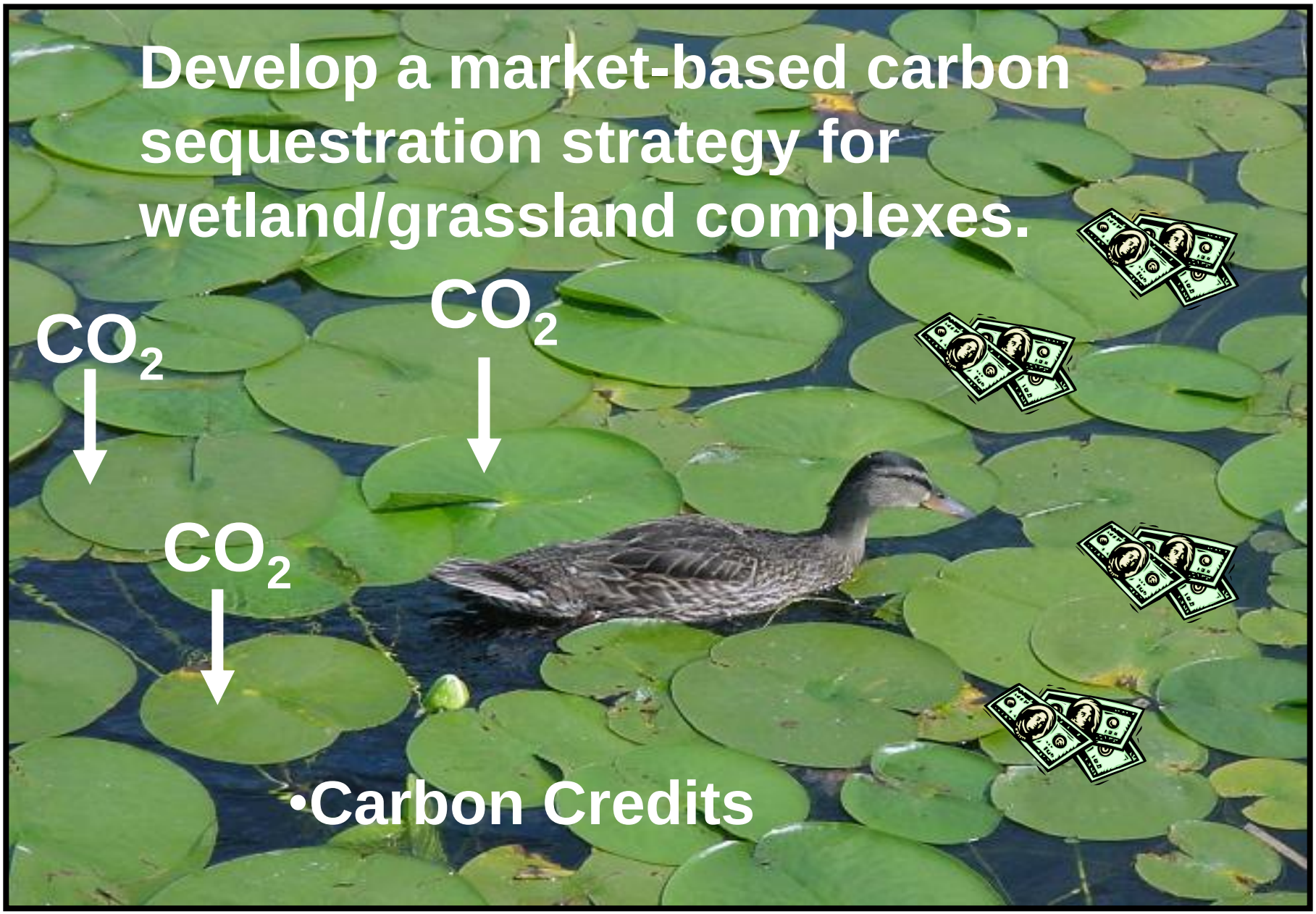
Terrestrial Field Validation Test Goal



Why Ducks ?

- Prairie Pothole Region important and unique regional feature.
- Numerous ancillary benefits.
- Significant public and industrial interest.

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Terrestrial Field Validation Test Objectives

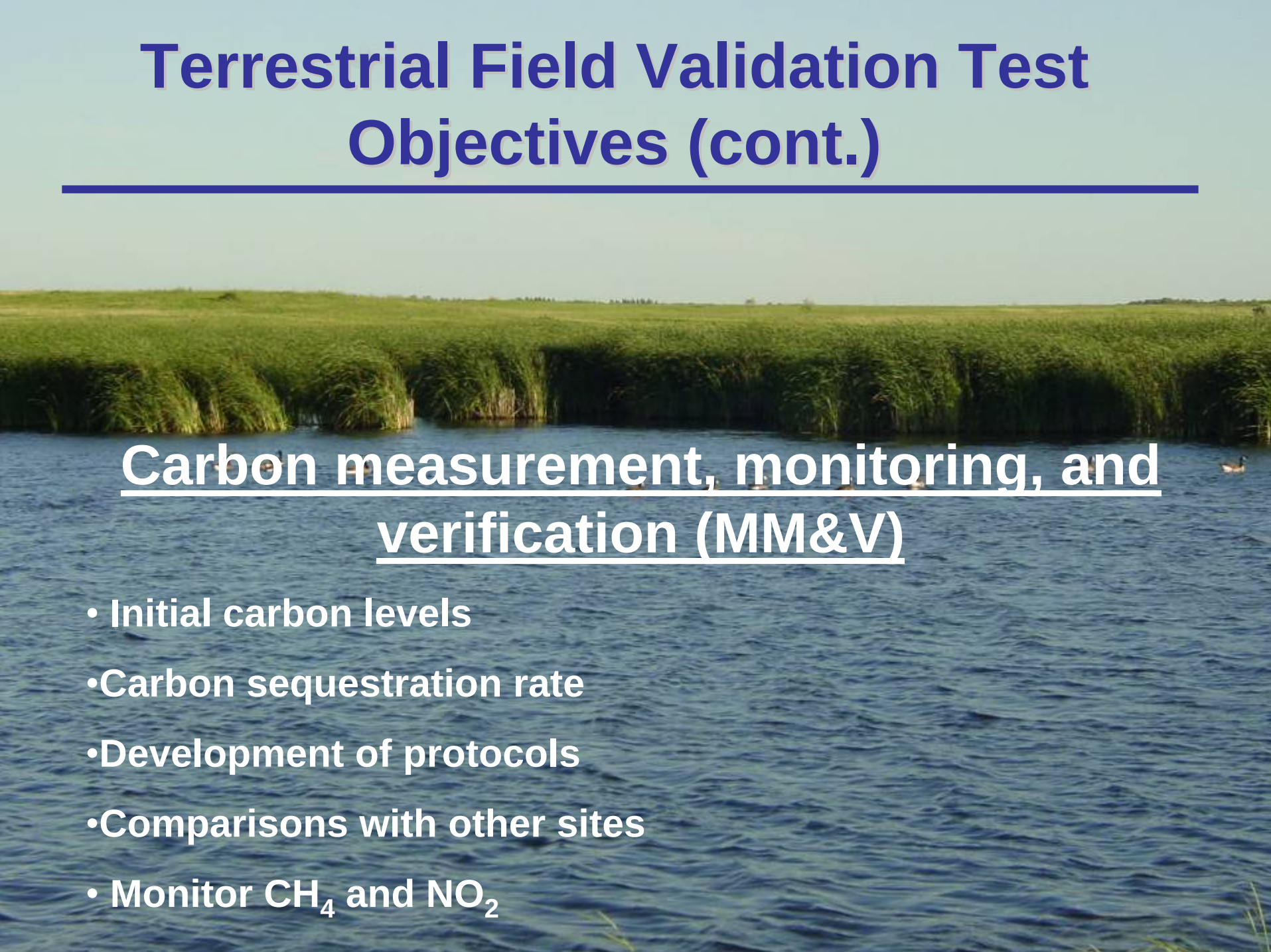
- Characterize field sites
- Site development and management
- Carbon sequestration MM&V
- Development of carbon offset protocols and standards
- Economic analysis

Terrestrial Field Validation Test Objectives (cont.)

Site development and management

- Develop wetland management practices
- Restoration activities

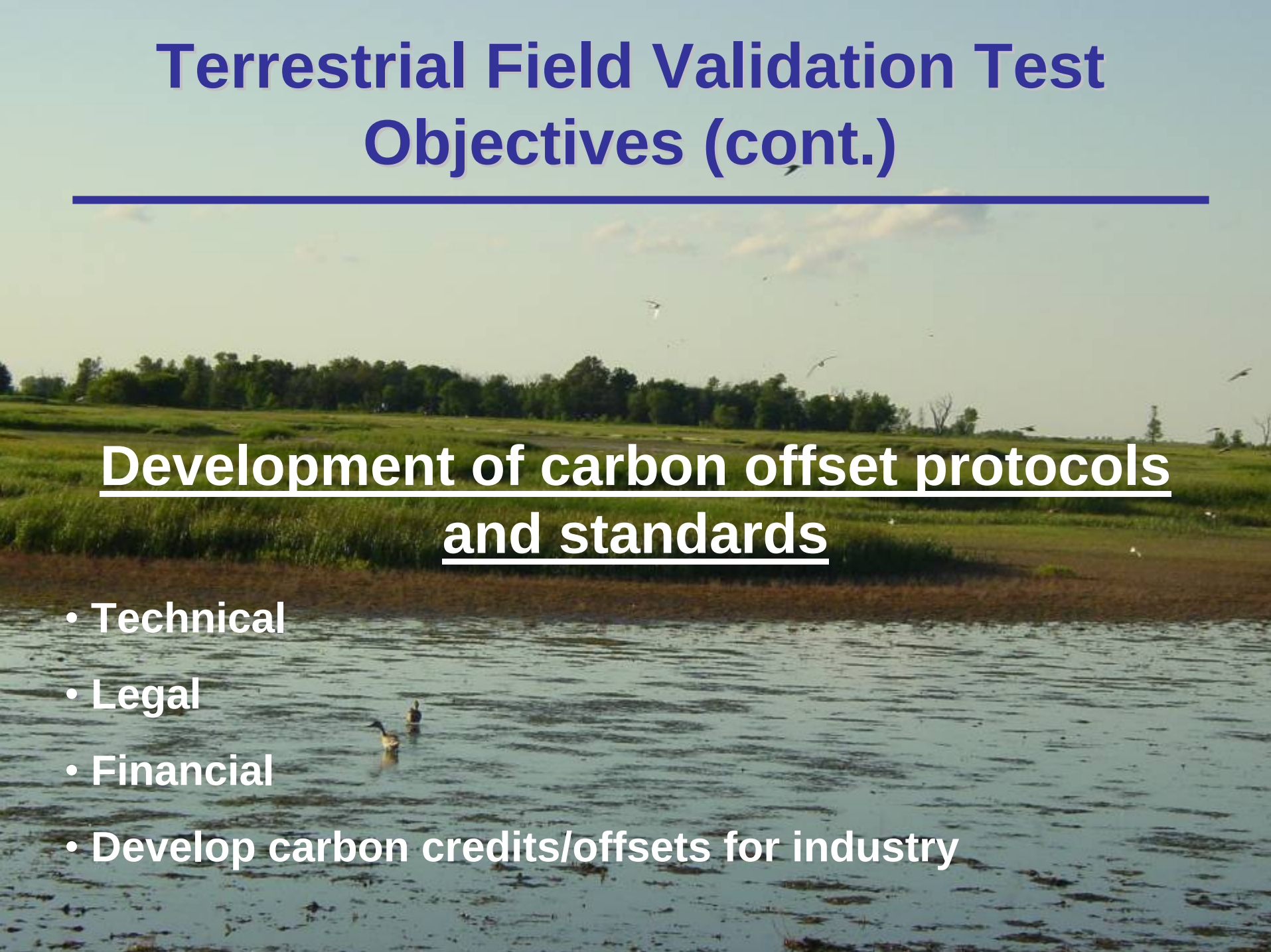
Terrestrial Field Validation Test Objectives (cont.)



Carbon measurement, monitoring, and verification (MM&V)

- Initial carbon levels
- Carbon sequestration rate
- Development of protocols
- Comparisons with other sites
- Monitor CH_4 and NO_2

Terrestrial Field Validation Test Objectives (cont.)



Development of carbon offset protocols and standards

- Technical
- Legal
- Financial
- Develop carbon credits/offsets for industry

Field Validation Test Objectives (cont.)

Economic Analysis

- Quantify costs with respect to carbon credit value (cost-benefit analysis)
  - Short and long term (commodity price impacts)
- Review indirect benefits
  - Water quality
  - Erosion control
  - Flood buffering
  - Recreational and wildlife benefits

Additional Tasks

Public Outreach and Education

- Videos produced by PPTV
- Fact sheets
- Public outreach plans
- Database enhancement
- GIS and modeling efforts (map products)

Phase II Regional Characterization

Goal: To continue regional characterization from Phase I and to provide data management for demonstration projects for the purpose of identifying opportunities for future field validation tests and/or commercialization.

- Define required data
- Collect and organize the data
- Enhance/expand Decision Support System (DSS)

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Defining and Collecting Data

- Refine Phase I regional characterization data
  - Updating data
  - Fill in data gaps
  - Assess new data needs
    - Economics
    - Regulatory

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Defining & Collecting Data (cont.)

- The “not so readily available” data
- Partners key

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Decision Support System

Goal: Enhance DSS with information and tools to support new opportunities.

- Digital Sequestration Atlas
- Sequestration cost analysis
- Refined capacity estimates
- Project-specific warehouse

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Digital Sequestration Atlas

DIGITAL Sequestration Atlas

- Core Photos
- Cross Sections
- Structrure Maps
- Geophysical Information
- Sequestration Mechanism
- Engineering Information
- Logs

XYZ Field

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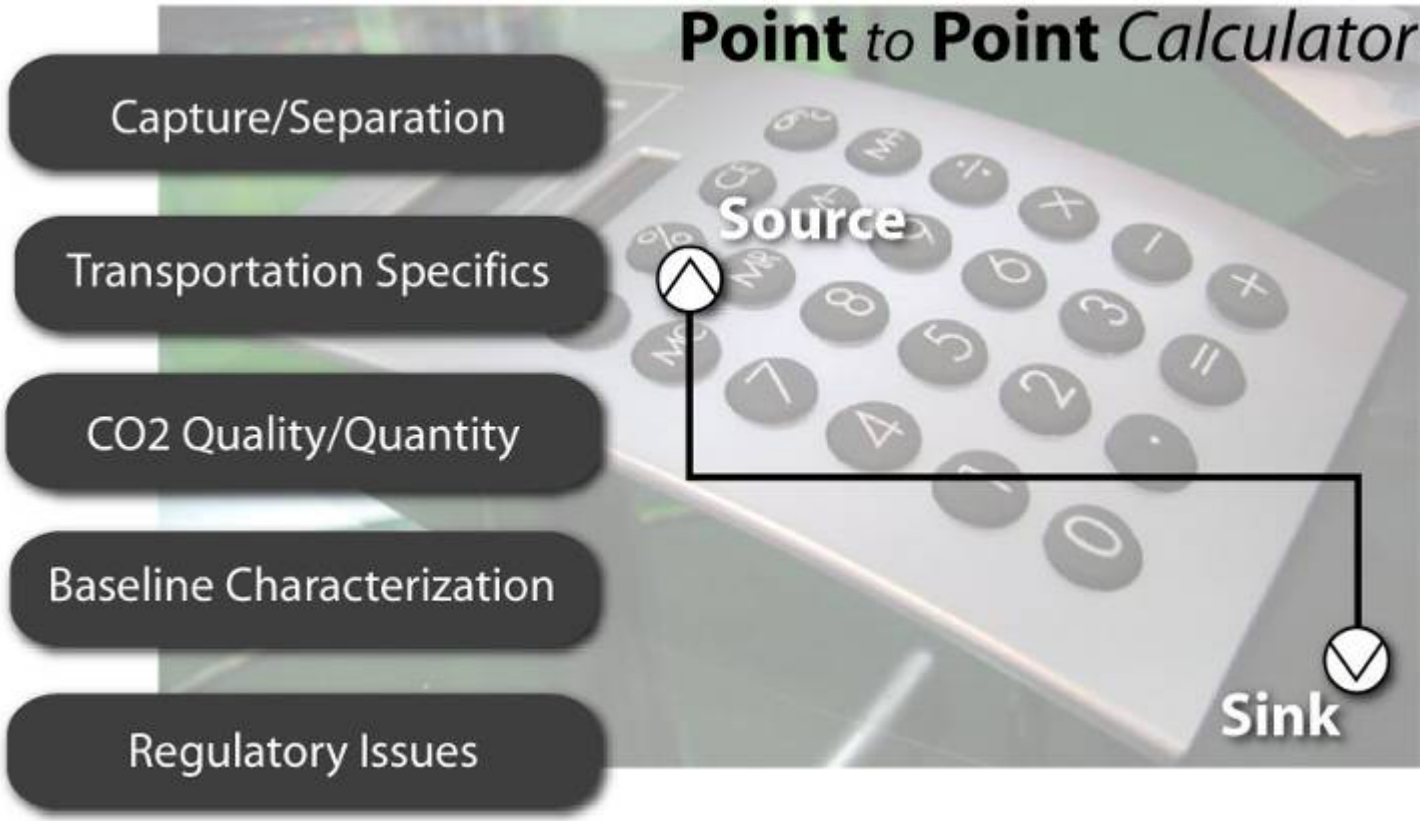
Sequestration Cost Estimator



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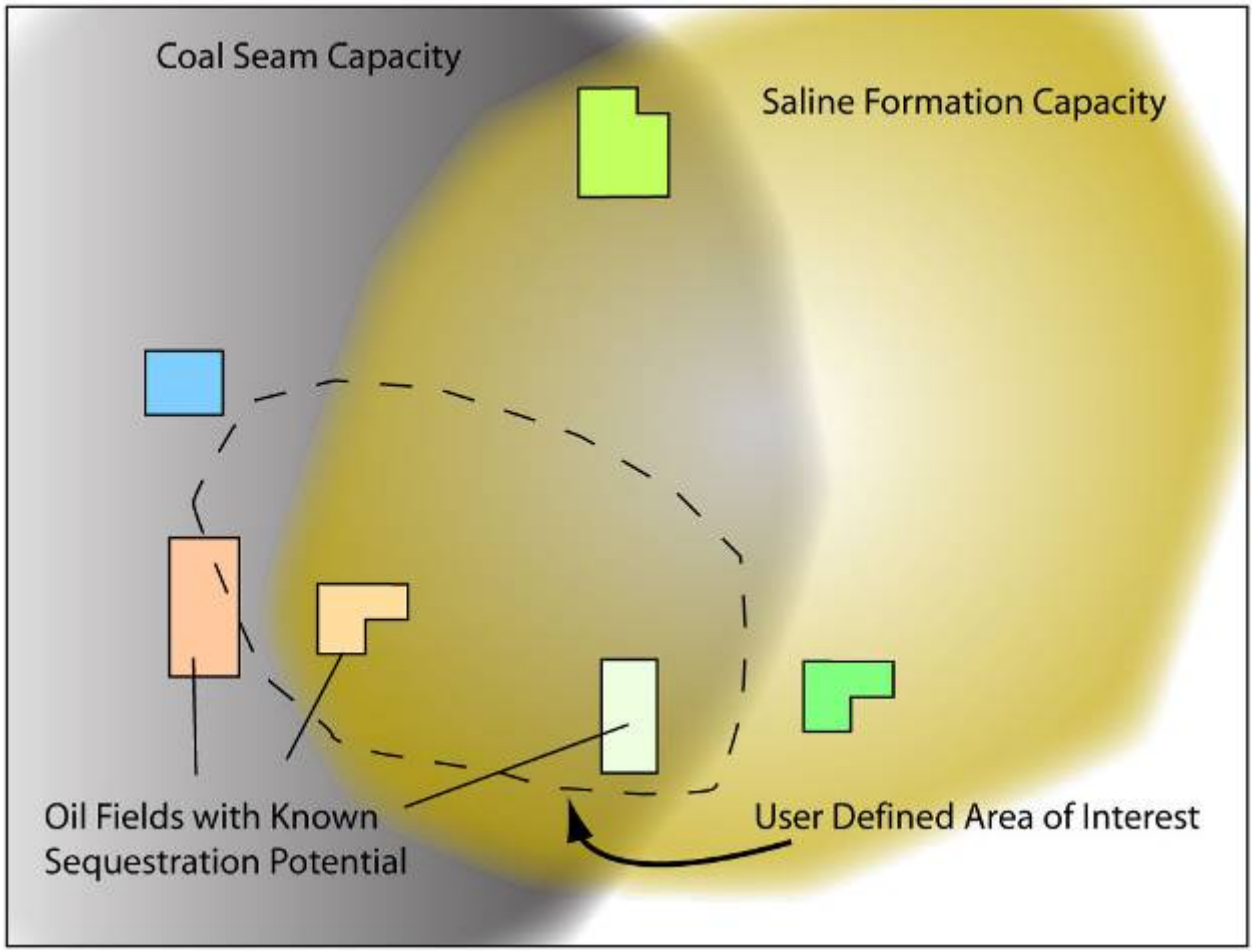
Refined Capacity Estimates



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Project-Specific Warehouse

- Encourage and facilitate data sharing within project
- File transfer
- Warehouse to contain project data
- Shared space for common components

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Research Safety, Regulatory, and Permitting Issues

- Permitting action plans will be designed for each field validation test:
  - Applications for required permits will be submitted to the appropriate local, state/provincial, and federal regulatory agencies.
  - Courses of action will be developed to address key safety and regulatory issues.
  - A site health and safety plan will be developed.

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Research Safety, Regulatory, and Permitting Issues (cont.)

- The developing regulatory framework of the PCOR Partnership region will be assessed.
- Partners in this endeavor include:
  - Interstate Oil and Gas Compact Commission
  - Western Governor's Association
  - Key state and provincial regulatory bodies

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Research Safety, Regulatory, and Permitting Issues (cont.)

- A Safety, Regulatory, and Permitting Road Map document will be developed.
  - Include future regulatory requirements for sequestration projects in the PCOR Partnership region

Phase II Outreach Approach

- Dual outreach focus
  - Outreach to general population
  - Focused outreach for validation tests
- Utilize established outreach networks
- Build on the Phase I outreach activities
- Participate in RCSP Outreach Working Group

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Phase II Expanded Toolbox Building on the Basics

- Expanded set of fact sheets
  - Phase II PCOR Partnership program update
  - A fact sheet for each of the four Phase II sequestration validation tests
- PCOR Partnership display booth (new)

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Phase II – Expanded Toolbox Public Web Site

- Add new topics and capabilities
  - Regional summary of sequestration potential and opportunities
  - In-depth information on the region through online topical reports (Phase I products)
  - Background on carbon-trading and sequestration projects
  - Sequestration “news”
- Update and expand Web pages on NETL partnership program and PCOR Partnership region and members

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Phase II – Expanded Toolbox Television Productions

- Produce and promote four new Public Television relating regional projects to NETL program and global context
  - Carbon-trading markets
  - Terrestrial sequestration
  - Geologic sequestration
  - Sequestration and global warming
- Continue to distribute "CO_2 Sequestration – Nature in the Balance" DVDs and promote in other public television markets

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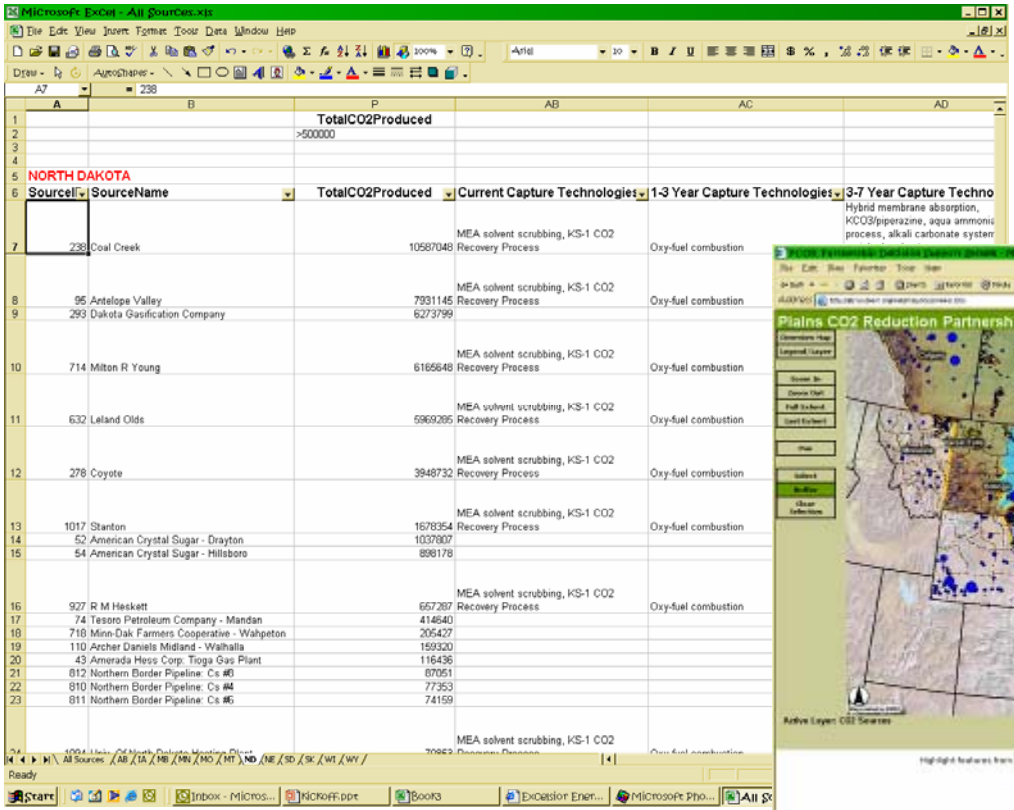
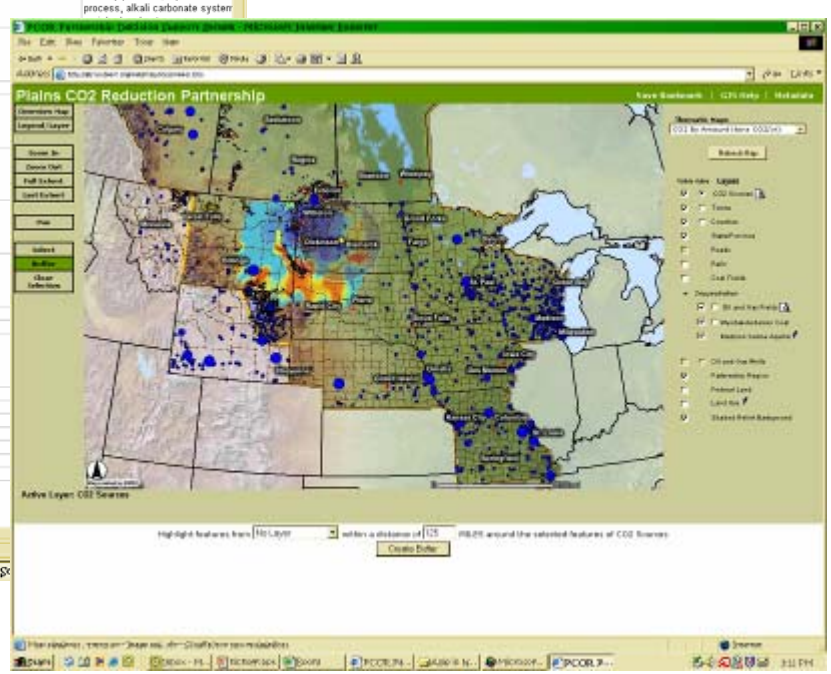
Matching of Source – Technology Pairs with Sinks



	A	B	P	AB	AC	AD
1			TotalCO2Produced			
2			>500000			
3						
4						
5	NORTH DAKOTA					
6	SourceID	SourceName	TotalCO2Produced	Current Capture Technologies	1-3 Year Capture Technologies	3-7 Year Capture Techno
7	238	Coal Creek	10587048	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	Hybrid membrane absorption, KCO3/piperazine, aqua ammonia process, alkali carbonate system
8	95	Antelope Valley	7931145	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
9	293	Dakota Gasification Company	6273799			
10	714	Milton R Young	6165648	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
11	632	Leland Olds	5969285	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
12	278	Coyote	3948732	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
13	1017	Stanton	1678354	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
14	52	American Crystal Sugar - Drayton	1037807			
15	54	American Crystal Sugar - Hillsboro	898178			
16	927	R M Heskett	657287	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	
17	74	Tesoro Petroleum Company - Mandan	414640			
18	718	Minn-Dak Farmers Cooperative - Wahpeton	205427			
19	110	Archer Daniels Midland - Walhalla	159320			
20	43	Amerada Hess Corp: Tioga Gas Plant	116436			
21	812	Northern Border Pipeline: Cs #3	87051			
22	810	Northern Border Pipeline: Cs #4	77353			
23	811	Northern Border Pipeline: Cs #5	74159			
24	1094	Univ. Of North Dakota Heating Plant	70853	MEA solvent scrubbing, KS-1 CO2 Recovery Process	Oxy-fuel combustion	



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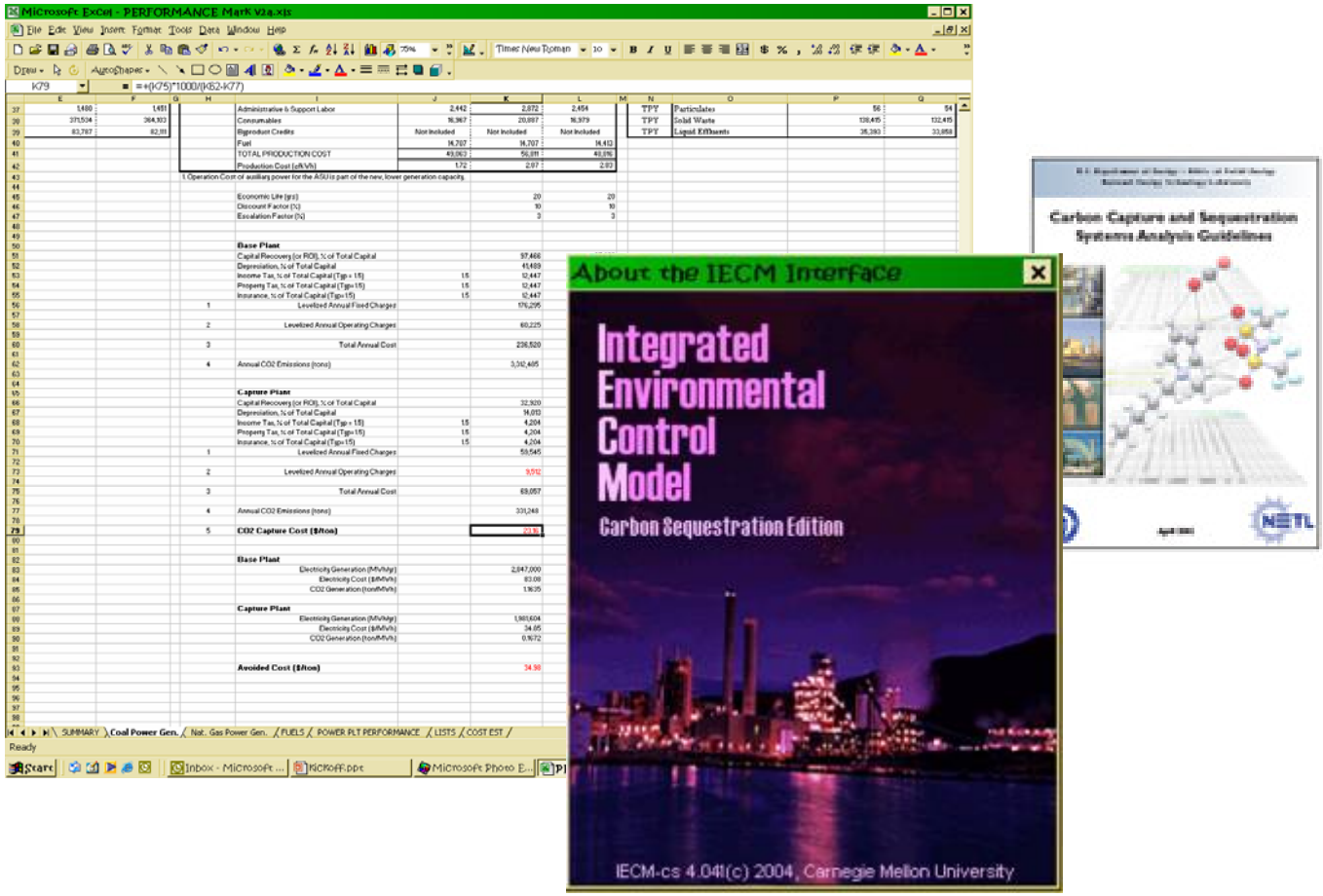
Economic Assessment of Representative Source–Technology–Sink Combinations



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Utilizing Wind Energy for CO_2 Compression

The generation and utilization of wind power to support energy requirements of two CO_2 compressors at Dakota Gasification Company will be analyzed.

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Development of CO_2 Management Plan for Excelsior Energy

The CO_2 sequestration opportunities that are available for Excelsior's planned Mesaba power plant will be assessed. Sink–source pairs specific to Excelsior operations will be identified and ranked according to engineering, economic, and public acceptance considerations.

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How Can the PCOR Partnership Add Value?

The PCOR Partnership Will: Catalog, Catalyze, and Monetize

- We provide regional databases that ***catalog*** sources and sinks and help to determine what infrastructure is needed.
- We ***catalyze*** projects by brokering meetings with appropriate industrial participants.
- We use our demonstration and validation activities to provide the technical and economic foundation needed to ***monetize*** carbon credits.

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PHASE II IS UNDER WAY!!!

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